2012 IEEE International Conference on Consumer Electronics (ICCE)

Low-Cost Efficient Interactive Whiteboard

Massimo Camplani[1], Luis Salgado[1] and Romolo Camplani[2]
[1]Grupo de Tratamiento de Imágenes, Universidad Politécnica de Madrid, Spain.
[2]Dipartimento di Elettronica e Informazione, Politecnico di Milano, Italy.

***Abstract*--In this paper we present a low-cost efficient Interactive Whiteboard that, by fusing depth and video information provided by a low-cost depth camera, is able to detect and track user movements.**

I. INTRODUCTION

Interactive Whiteboard devices (IWB) have been widely used in teaching environments or in conference rooms. IWB presents several advantages with respect to a conventional whiteboard: it allows saving whiteboard contents, integrating other multimedia contents (videos, and images) and it helps to catch audience attention with interactive and enhanced drawing tools. IWBs can be based on different technologies: resistive or capacitive active surfaces; optical technologies based on laser systems or active stylus devices; ultrasonic transmitters usually applied on the whiteboard corners. Despite these technologies guarantee an efficient tracking system of the user-whiteboard interactions, they are usually expensive and cannot be easily ported or moved into different environments. Moreover, these systems can only detect user-whiteboard interaction by relying on surface contact, and no free-hand gesture capture is contemplated.

In this paper we present an efficient, low-cost IWB system based on a commercial low-cost depth sensor [1]. The main advantage of this system is its high level of portability: it can be integrated with common equipments like monitors or projector systems and off-the-shelf PCs. Moreover, it also allows to integrate gesture recognition, hence, to broaden the user-whiteboard interaction possibilities.

The availability in the market of low-cost depth/video sensors with good resolution is attracting the attention of the computer vision community and industry. In particular, many human-computer interaction applications (e.g., video games) have been developed [2], where the player moves in obstacle-free environments. In [3] the use of a depth camera to detect user interaction with a not instrumented surface has been proposed. The advantage of this work is that the surface can be of any shape; however the proposed system cannot achieve the performance of capacitive touch screens. In [4] a multi-touch immersive environment that combines depth cameras and projectors has been presented.

For the best of authors' knowledge, depth camera sensors technology has not been yet employed in IWB systems. The only similar approach, but based on a different technology (infrared source-receiver pairs), was proposed in [5].

This work has been supported by the Ministerio de Ciencia e Innovación of the Spanish Government under project TEC2010-20412 (Enhanced 3DTV). Massimo Camplani would like to acknowledge the EU and the UPM for supporting his research activities through the Marie Curie-Cofund research grant.

In this paper we present an IWB system that is based on a low-cost depth/video sensor [1]. The system can be integrated with off-the-shelf equipments like projectors, flat screens and PCs. User movements are detected and analyzed by combining video and depth information. The most innovative feature of this system is the ability to detect free-hand gestures thanks to the analysis of the depth information and, hence, to broaden the user-whiteboard interaction possibilities. In fact, depth information is crucial in order to accurately interpret user's gesture and movements thus allowing to discriminate intentional interactions with the whiteboard (whether writing or other pre recorded gestures) and unintentional ones, like gestures towards the audience. However, depth only information is not sufficient to efficiently track hand/whiteboard surface interactions due to limitations related to the camera depth resolution (as pointed out in [3]): a video based tracking approach is needed to overcome this problem.

II. SYSTEM OVERVIEW

The scheme of the proposed IWB system is shown in Fig.1. The depth camera acquires video and depth information of the scene and sends it to a Processing Unit (PU) that combines depth and video information to extract the user silhouette and to detect and track hand movements. Then, the extracted movements are used to update the whiteboard contents.

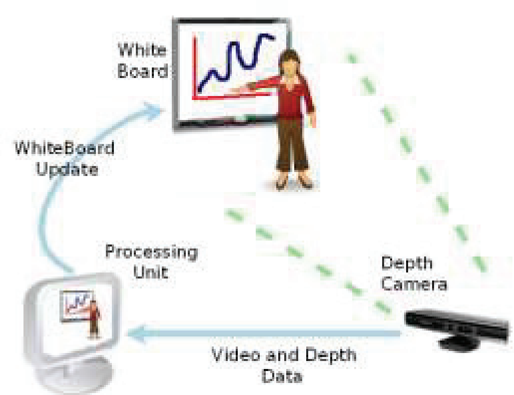

Fig. 1. Interactive Whiteboard system scheme.

The overall system is portable since it does not require any particular whiteboard surface: it could be a conventional screen connected to the PU, or a white flat region on which images are rendered by a projector connected with the PU (that is an off-the-shelf PC since no specialized hardware is required). The role of the PU is fundamental to properly manage video and depth data and to guarantee reliable tracking and gestures recognition. The block diagram of the processing unit tasks is shown in Fig.2.

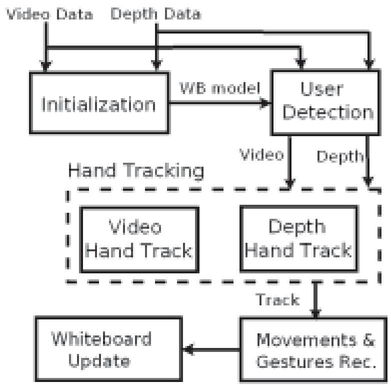

Fig. 2. Workflow of the Processing Unit tasks.

The system is initialized with video and depth data to correctly identify the area in the images where the whiteboard is situated. Moreover, the Mixture of Gaussians background modeling algorithm [6] is employed to obtain a reliable estimation of the whiteboard depth map and color model. When the system is initialized, the user full body is detected by using a depth based lightweight foreground segmentation algorithm (available in libraries [7]). Our tests have shown that this algorithm is robust enough to identify the region occupied by the user where the hand tracking is performed.

The combined analysis of depth and video data allows to perform efficiently hand tracking and enables new interaction between user and whiteboard thanks to free-hand gesture detection. The depth information is used to detect different user gestures that are employed to activate specific whiteboard functions/events (i.e. *swipe* motion to clean the whiteboard or *click* to select different painting tools). The video information is used to track the hand/surface interaction that cannot be discriminated by using only the depth information.

Therefore, the proposed hand tracking module is based on the combination of two independent trackers: depth based tracking module that makes use of the efficient algorithm presented in [7]; video based tracking is performed with the KLT algorithm [8], that is initialized with the points extracted from the hand region identified by the depth based tracker. The trackers are combined considering the relative distance between user and the whiteboard: when the user is close to the whiteboard and interacts with its surface the video based tracker results are used to update the whiteboard contents. On the contrary, when the user is far from the whiteboard surface, the depth based tracker is used to detect free hand gesture movements. Moreover, video information can be useful to refine the contours of the hand silhouette obtained with the depth map that is usually very noisy near edges, hence improving the tracking quality, thanks to a more accurate estimation of the hand's center of mass. The resulting hand tracked positions are analyzed to detect movements corresponding to specific free-hand gestures or drawing actions. Finally, the whiteboard content is updated.

III. RESULTS

In Fig. 3(a) an example of the IWB system using a conventional screen is shown. As it can be noticed from Fig. 3(c) the depth resolution does not allow to accurately detect the hand-screen interaction when the hand is in the screen plane since, as previously described, only depth information cannot efficiently detect the hand-whiteboard contact. For this reason, the visual information data is used to correctly segment the hand (Fig.3 (d)) and to obtain a precise tracking of its movements.

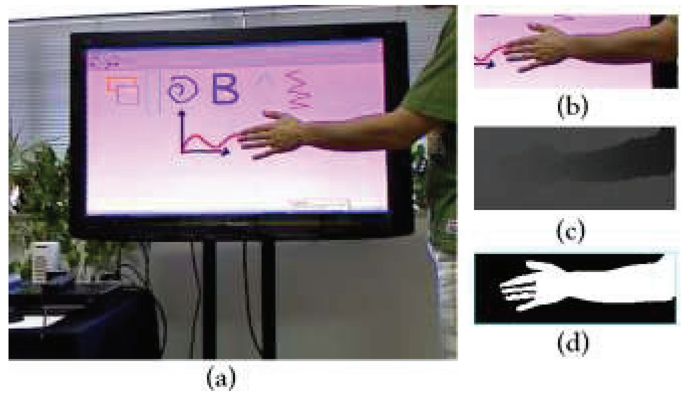

Fig. 3.IWB usage (a). Detail of the video information (b). Detail of the depth map (b), hand segmentation with video information (d).

IV. CONCLUSIONS AND FUTURE WORKS

In this paper we present a low-cost Interactive Whiteboard system based on the integration of a low-cost depth camera with off the shelf equipments like projectors or flat screens. It allows to efficiently track user movements and free-hand gestures thanks to the combined analysis of video and depth data. The proposed system is very attractive since it is able to offer easy portability, low cost implementation and wide applicability. As future works we plan to enrich the free-hand gesture recognition module and to improve the drawing tool capability with the introduction of 3D object drawing.

REFERENCES

[1] Kinect Camera. www.xbox.com/kinect

[2] A. Bleiweiss, D. Eshar, G. Kutliroff, A. Lerner, Y. Oshrat, and Y. Yanai. "Enhanced interactive gaming by blending fullbody tracking and gesture animation". *In ACM SIGGRAPH ASIA.* 2010.

[3] A. D. Wilson. "Using a depth camera as a touch sensor". *In ACM International Conference on Interactive Tabletops and Surfac*es 2010.

[4] A. D. Wilson and H. Benko. "Combining multiple depth cameras and projectors for interactions on, above and between surfaces," *Annual symposium on User interface software and technology*, ACM, 2010.

[5] J.C. Lee "Low-Cost Multi-point Interactive Whiteboards Using the Wiimote" http://johnnylee.net/projects/wii/

[6] C. Stauffer, and W. E. L. Grimson, "Adaptive background mixture models for real-time tracking," *IEEE Computer Society Conference on Vision and Pattern Recognition,* vol.2, pp. 2246-2252, August 1999.

[7] OpenNI libraries. www.openni.org

[8] B. D. Lucas and T. Kanade. "An iterative image registration technique with an application to stereo vision," *In Proceedings of the 7th international joint conference on Artificial intelligence (IJCAI'81), Vo*l. 2. 1981.